

# Marketing Response Analysis Based Dynamic Pricing for Information Products with Piracy Effects

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**Abstract:** *The problem of dynamic pricing for legal copy of information products is researched in market setting of existing piracy products. Information products are experienced products, which determine different customers' perceived value in a wide range. For this, an estimation method based on marketing response analysis is developed for estimating customers' value distribution, and further a pricing model for legitimate information products is put forward. The experimental results show that the proposed method can help the suppliers know the dynamic change of customer perceived value of legitimate information products and piracy ones, so as that the price can be adjusted timely and reasonably, through which piracy products' competition effect can be inhibited and eventually profits for legitimate products can be maximized.*

**Key words:** *information product; piracy; dynamic pricing; perceived value*

## 1 Introduction

This study focused on the charge by periods model and examined the problem of dynamic pricing for legal copy of information products in market setting of existing piracy products. Digital information products can be freely reproduced, and almost do not suffer from the marginal costs, thus, pricing is primarily based on the perceived value of consumer towards the products<sup>[1]</sup>. However, consumer perceived value often changes dynamically, indicating that: (1) Value experience effect: information product is a kind of experience goods; consumers' perception of value varies with the using experience dynamically; (2) Network externality effect: consumers' perceived value will be higher if they perceived a higher degree of popularity of information products in their social network. Because of the dynamic change of perceived value, the suppliers need to adjust the price dynamically so that revenue can be maximized.

The difficulty of this problem is that based on the charge by periods model, customers need to make a decision about whether to continue using the product after the end of payment cycle, hence, the suppliers should follow the tracks of and get to know the dynamic change of various consumers' perceived value, while perceived value is determined by the customer subjective feelings and is difficult to measure objectively. Based on the fact that in the actual operation, suppliers can keep a record of customers' market response data under the current pricing strategy, this study analyzed the proportional structure of various customers' perceived value in the market through the method of marketing response analysis called "from the effect to the cause". Accordingly, we can calculate the distribution of consumer perceived value in the next stage and obtain the optimal revenue of suppliers at that time.

Due to the digital technology, the duplication cost of information products is very low and the production capacity is no limited. Therefore, the key factor that affects information product pricing is the view of customers, namely, consumer perceived value. Dynamic pricing also need to consider how to regulate the matching problem between supply and demand through the price to achieve maximum revenue <sup>[2]</sup>. Nevertheless, in essence, digital information products have no inventory problems; the primary factor that affects the change of price is the dynamic change of consumer perceived value. Aron. etc. (2006) proposed intelligent agent technology to analyze value preferences of different consumers, enabling customization of information products and optimizing product prices in real time <sup>[3]</sup>. However, Aron did not examine the effect of piracy on information products and the proposed pricing model is not suitable for the charge by periods model.

In the aspect of the piracy of information products, Cremer (2009) stated that copyright protection is costly; furthermore, excessive copyright protection would hinder the speed of diffusion of information products, thus it is not the optimal enforcement policy to prevent piracy <sup>[4]</sup>. Therefore, since piracy could not be prohibited completely under the current law and moral, a lot of information products suppliers tend to limit the negative impact of piracy on revenue through reasonable pricing strategy. As early as 1989, Besen etc. analyzed how to adjust copying royalties to maximize profits with the existence of piracy <sup>[5]</sup>. Khouja (2007) introduced saturation effect parameter of piracy market into the pricing model of information goods, and demonstrated that piracy would accelerate the saturation of legitimate market, and would enhance the interest by potential customers, which may lead to the expansion of legitimate market scale <sup>[6]</sup>. The charge by periods is a repeat purchase model. On the basis of this model, due to the change of perceived value, some legitimate customers will turn into piracy customers, and some piracy customers will also turn into legitimate customers. It is necessary for the suppliers to know about not only the change of consumer perceived value towards legitimate information products but also the dynamic one towards piracy information products. In this way, the price could be adjusted scientifically. Regarding to the charge by periods model, in order to follow the tracks of and get to know the change of perceived value, frequent use of market survey requires enormous business cost, which is not feasible in reality. Even so, the results of marketing response analysis can be the reference for this study. Marketing response analysis refers to customer behavior in response to a marketing strategy. The behavioral data can provide marketing decision makers with a better understand about the market. For example, Bucklin (1998) put forward that market could be segmented by analyzing customer response behavior, making marketing activities more targeted <sup>[7]</sup>. Whereas, in market setting of existing piracy information products, there is still no particularly effective way of estimating the distribution of perceived value towards legal copy and piracy based on marketing response data.

## 2 Pricing model of digital information products in the charge by periods model

We assume that the suppliers need to reprice according to their forecasts of future market at each end of pricing cycle. If the current time stage is  $t$ , then the next pricing stage is  $t+1$ . Let  $Z$  denote legitimate products and  $D$  denote piracy products, Let  $\eta_z^{t+1}$  denote the expectation of per-

ceived value towards legitimate products in the entire market at the time stage  $t$ ,  $s_z^{t+1}$  denote standard deviation,  $r_z^{t+1}$  denote the distribution of perceived value towards legitimate products in the entire market, which is drawn from:  $r_z^{t+1} \sim N(\eta_z^{t+1}, \sigma_z^{t+1})$ . In a similarly way, let  $r_d^{t+1}$  denote the distribution of perceived value towards piracy products in the entire market, which is drawn from:  $r_d^{t+1} \sim N(\eta_d^{t+1}, \sigma_d^{t+1})$ . We assume that the usage cost of piracy is a known constant  $c$ , and the pricing of legal copy at the time stage  $t+1$  is  $p^{t+1}$ . Let  $Pr_z^{t+1}$  denote the average probability that each customer would purchase legal copy in the market, we obtain:

$$\begin{aligned} Pr_z^{t+1} &= Pr(r_z^{t+1} - p^{t+1} > r_d^{t+1} - c \mid \hat{Q}_z^{t+1} - p^{t+1} > 0) \\ &= \int_{p^{t+1}}^{+\infty} \frac{1}{\sqrt{2\pi}\sigma_z^{t+1}} \exp\left(-\frac{(r_z^{t+1} - \eta_z^{t+1})^2}{2(\sigma_z^{t+1})^2}\right) dr_z^{t+1} \int_0^{r_z^{t+1} - p^{t+1} - c} \frac{1}{\sqrt{2\pi}\sigma_d^{t+1}} \exp\left(-\frac{(r_d^{t+1} - \eta_d^{t+1})^2}{2(\sigma_d^{t+1})^2}\right) dr_d^{t+1} \end{aligned} \quad (1)$$

Eq. (1) implies that if there is no piracy products, when  $(r_z^{t+1} - p^{t+1}) > 0$ , customers will tend to purchase legitimate products, however, due to the existence of piracy, it is necessary for the suppliers to reduce the price appropriately to make  $r_z^{t+1} - p^{t+1} > r_d^{t+1} - c$ . As such, piracy restricts the pricing space of legal copy, namely, **piracy products' competition effect** against legitimate products.

Let  $N^{t+1}$  denote user base at the next pricing cycle known by the suppliers,  $R^{t+1}$  denote the revenue at the time stage  $(t+1)$ ,  $\arg()$  denote inverse function, thus the optimal pricing function at the time stage  $(t+1)$  is:

$$p^{t+1} = \arg(\max_{p^{t+1}} p^{t+1} \times N^{t+1} \times Pr_z^{t+1}) \quad (2)$$

Eq. (1) and Eq. (2) imply that the crux of the matter is how to predict the probability distribution of perceived value towards legitimate products in the market at the next time stage  $(t+1)$ :  $r_z^{t+1} \sim N(\eta_z^{t+1}, \sigma_z^{t+1})$  and that towards piracy products:  $r_d^{t+1} \sim N(\eta_d^{t+1}, \sigma_d^{t+1})$  on the basis of market information at the current time  $t$ .

### 3 Estimate the market's perceived value distribution on the method of marketing response

#### 3.1 Estimate the customer distribution matrix and perceived value distribution on the method of marketing response

In order to estimate the entire perceived value distribution of next period, we need to predict the current customer distribution matrix  $h^t$ . Assumption that the current user base is  $N^t$ , market structure of different customer type is  $H^t$ , let  $P^t$  denote product price at time  $t$ , let  $W^t$  denote sales of legitimate products. For calculation purposes, we cluster the matrix  $h^t$  in to

$G$  segments with the principle of similarity,  $g=1, 2, \dots, G$ . Let  $\hat{h}^g = (\hat{h}_{C_Q}^g, \hat{h}_{C_Z}^g, \hat{h}_{C_D}^g)$ ,  $C_Q, C_Z, C_D$  denote customer type of potential, legitimate and piracy, respectively. Let  $\varphi_g^t$  denote the probability of occurrence of customer distribution matrix of number  $g$  at time  $t$ . Based on the principle of

“from the effect to cause”. We can estimate customer distribution matrix and perceived value distribution accurately. Definite steps as follow:

Step 1: Let  $\Pr_{k,z}(p')$  as the probability of customer k purchase legitimate products,  $Pr_{sold}(g, p')$  denote the legitimate product being purchased by averaged one customer arrived, when the legitimate information product price is  $p'$  and customer distribution matrix is g. According to the principle of Equation (1), we can calculate  $Pr_{sold}(g, p')$  as follows:

$$Pr_{sold}(g, p') = \sum_{l \in L} H_l^t \times \sum_{k=1}^K \hat{h}_{l,k}^g \times \Pr_{k,z}(p') \quad (3)$$

Step 2: Let  $Pr_{sold}(W^t | N^t, g, p')$  denote the probability of  $W^t$  legitimate products being sold, when the legitimate information product price is  $p'$ , customer distribution matrix is g, current user base is  $N^t$ , according to the distribution of Binomial, we can calculate  $Pr_{sold}(W^t | N^t, g, p')$  as follows:

$$Pr_{sold}(W^t | N^t, g, p') = C_{N^t}^{W^t} (Pr_{sold}(g, p'))^{W^t} \times (1 - Pr_{sold}(g, p'))^{N^t - W^t} \quad (4)$$

Step 3: When the legitimate information product price is  $p'$ , customer distribution matrix is g, current user base is  $N^t$  and there are  $W^t$  legitimate products being sold, then at time t, the probability of the number g of matrix  $h^t$  is:

$$\varphi_t^g = Pr(g | N^t, W^t, p') = \frac{Pr_{sold}(W^t | N^t, g, p')}{\sum_{g=1}^G Pr_{sold}(W^t | N^t, i, p')} \quad (5)$$

Step 4: Every market parameters is  $h_{l,k}^t = \sum_{g=1}^G \varphi_t^g \times \hat{h}_{l,k}^g$  in matrix  $h^t$  at time t. According this, we can get customer's perceived value distribution matrix  $h^t$ .

Based on a simple grouping statistical method, suppliers know perceived value expectation and customer's perceived value distribution matrix  $h^t$ , they can get the probability distribution of next period's entire market perceived value  $r_Z^{t+1} \sim N(\eta_Z^{t+1}, \sigma_Z^{t+1})$  and  $r_D^{t+1} \sim N(\eta_D^{t+1}, \sigma_D^{t+1})$ .

### 3.2 Estimate market perceived value distribution in the future

Information products have obvious characteristics of network externality; Customers' perceived value will increase with the increase of user base. Because of this characteristic, customers will amend their perceived value toward products after an experience period.

Considering the aspect of network externality, let  $\Delta \lambda_N^t = (N^t - N^{t-1}) / N^{t-1}$  denote the rate of change of user base, let  $\hat{1}_l C_Q, C_Z, C_D$ ,  $\alpha_l$  denote perceived value impact factor of customer l, it caused by the change rate of user base. Influenced by network externality, the perceived value of customer l toward legitimate products at the period of (t+1) can be described as:

$$\bar{\eta}_{l,z}^{t+1} = (1 + \Delta\lambda_N^t) \times (1 + \alpha_l) \times \bar{\eta}_{l,z}^t \quad (6)$$

Considering the aspect of experience goods, let  $\tau_l$  denote the average change rate of practical utility perception with the use of a period of time, compared with legitimate and piracy expected utility. After a charge period, the perceived value toward legitimate products of customer  $l$  can be revised as

$$\bar{\eta}_{l,z}^{t+1} = (1 + \tau_l) \times (1 + \alpha_l \times \Delta\lambda_N^t) \times \bar{\eta}_{l,z}^t \quad (7)$$

Similarly, we can get  $\bar{\eta}_{l,D}^{t+1}$ , and estimate market perceived value distribution in the future.

## 4 Experiment

### 4.1 Experiment design

Assumption product price  $P'$  is 15 Yuan, after a charge period, the sales of legitimate product  $W'$  is 20000. Assumption the current user base  $N'$  is 100000, the scale structure of customer type potential, legitimate and piracy  $H' = (0.50, 0.30, 0.20)$ . Assumption the growth rate of every charge period is 2%. In this paper, we assumption that the legitimate product interval of customer perceived value is  $[0.5, 50.5]$ , piracy product interval of customer perceived value is  $[0, 10.50]$ .

Network externality have different impact factor to perceived value of different type of customers. Because of no practical using experience, network externality has little influence to the customer type of  $C_Q$ . On the other hand, piracy information product and legitimate information product have approximate core functions, so network externality has same influence to the perceived value of legitimate and piracy products. In this paper we let  $\alpha_{C_Q} = 0.10$ ,  $\alpha_{C_Z} = \alpha_{C_D} = 0.50$ ; Because potential customers lack of using experience, there is no impact factor caused by value experience effect. Legitimate customer can perceive not only product's core functions, but also same auxiliary function, such as product update, breakdown maintenance. Thus, value experience effects of legitimate customers are greater than piracy customers. In this paper, we let  $\tau_{C_Q} = 0$ ,  $\tau_{C_Z} = 0.05$ ,  $\tau_{C_D} = 0.01$ .

### 4.2 Experiment result analysis

According to the basic setting of experimental parameters, we get the result:  $P^{t+1} = 22$  Yuan, profit is 39, 1500 Yuan, increasing over the previous period of 31%. The results reveal that through the analysis of marketing response, identifying the distribution of the active region of value customers, and the distribution of perceived value of main market players, then according to the Equation (2), we can get revenue maximization pricing. The experiment results demonstrate that scientific pricing strategy needs to know the distribution of the active region of value customers, and that can insure the profit of information product suppliers.

**Figure 1** analyzes the profit influence by network externality. Because the same network externality perception between legitimate and piracy customers, which is different from potential customers, we analyze the market ratio of potential customers. Figure 1 shows: With the change of network externality, dynamic pricing strategy is more suitable for high ratio potential customers. This is because: (1) The higher ratio of potential customers in the market, the greater market potential will have. Rapid increase of network externality will greatly affect the perceived value of potential customers. Although dynamic pricing strategy may produce a higher initial price, lead to some customers becoming piracy customers. But piracy products will expand network externality, some customers may become piracy users, while there are other customers will become legitimate customers; (2) With low ratio of potential customers, the increase of profit depend on the ability to incentive piracy users becoming legitimate users, but piracy and legitimate customers have the same network externality perception, network externality has same influence to legitimate and piracy products, at this time, suppliers decrease the price of legitimate products to expand the quantity of legitimate customers.

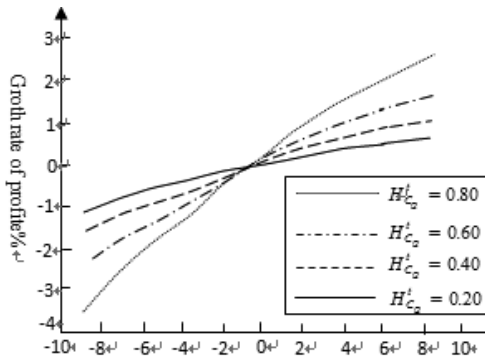


Figure 1

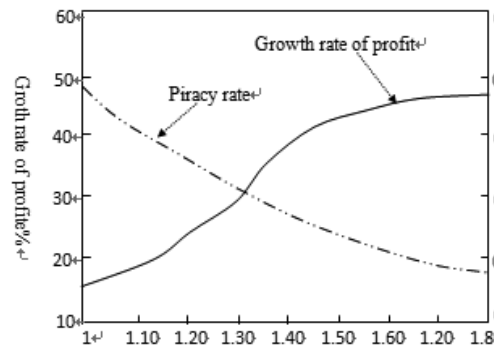


Figure 2

Competitive effect of piracy limits the profitability of legitimate suppliers. From the analysis above, when products launched to market in early days, the majority are potential customers. Although piracy products on the market constitute unlawful competition effect to legitimate products, the proliferation of piracy products enhances the product's network externality accordingly, thereby enhancing the overall perceived value of product market. Dynamic pricing strategy is based on the dynamic change of perceived value to adjust the price of legitimate product scientifically. Expanding the network can play pirated external characteristics, and also to adjust pricing strategies to limit piracy competitive effect.

**Figure 2** is the influence to growth rate of profit and piracy rate from the different value experience between legitimate and piracy products. Because the value experience effect of potential customers is 0, this experiment neglects the market environment with high rate of potential customers, only assumption that potential customers have low market ratio ( $H_{C_0}^L = 0.20$ ). Figure 2 shows: (1) With the strategy of dynamic pricing, the value experience of legitimate product is greater than piracy product, leading to more conducive to reduce piracy and increase revenues. (2) When the value of experience gap ratio reaches a certain level,

there is no significant improvement in profit enhancing. This is because potential customers have no value experience effect, piracy users can't get the functions of legitimate product, just expand the gap of value experience is conducive to maintaining legitimate old customers. When market players have experience in the use of legitimate customers, product suppliers need to be appropriate to increase investment in technology to enhance the legitimate products with the relevant auxiliary functions, such as automatic product update, breakdown maintenance. Expanding the value experience gap between legitimate and piracy products to expand the gap of perceived value between legitimate and piracy products. Lower price will attract piracy customers to be legitimate customers, while expand value experience gap will maintain the loyalty of legitimate customers. Especially in the high piracy rates market, it needs to rely on dynamic pricing strategy to attract piracy customers to become legitimate customers, and thereby increasing product revenue.

## 5 Conclusion

This study proposed the method of marketing response analysis to estimate the distribution structure of various value customers, which solved the problem that consumer perceived value is difficult to estimate and ensure the feasibility of dynamic pricing. The results of theoretical research and simulation experiments indicated that this parameter estimation method allows suppliers to keep abreast of the dynamic changes about the value of legal copy and pirated products perceived by the current market. Consequently, the suppliers could adjust the product price timely in order to maximize the revenue. The piracy products could lead to the illegal market competition effects, however, on the other hand, they also facilitated the expansion of network externality and the value experience of free products. The dynamic pricing strategy that we proposed examined not only the customer purchase probability under the effect of piracy competition effects, but also investigated the effect of network externality and the value experience on consumer perceived value. Hence, our research model fully reflected the influence of piracy effects on revenue.

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